UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/016,437	12/10/2001	Nader Dutta	594-25576	5333

7590 02/22/2008

Jeffrey E. Griffin
WesternGeco Intellectual Property Department
10001 Richmond Ave.
Houston, TX 77042

EXAMINER	
JONES, HUGH M	

ART UNIT	PAPER NUMBER
2128	

MAIL DATE	DELIVERY MODE
02/22/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)
	10/016,437	DUTTA ET AL.
	Examiner	**Art Unit**
	Hugh Jones	2128

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _05 November 2007_.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-15 and 17-28_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _1-15 and 17-28_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _10 December 2001_ is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. Claims 1-28 of U. S. Application 10/016,437, filed 12/10/2001, are presented for examination.

Drawings

2. Figure 6-8 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g). Corrected drawings in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled “Replacement Sheet” in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

4. **Claims 1-5, 7-28 are rejected under 35 U.S.C. 102(a) as being clearly anticipated by de Kok (PCT search report, *2003*; including one of the inventors.) or** Huffman et al. (“H1”)

(The petrophysical basis for shallow-water flow prediction using multicomponent seismic data; THE LEADING EDGE SEPTEMBER 2001; pp. 1030-1036) or *in the alternative* under 35 USC 103 in view of Mallick et al. (inventor, 11/2000; of record; “Hybrid seismic inversion: A reconnaissance tool for deepwater exploration”).

5. **Claims 1-5, 7-15, 17-28 are rejected under 35 U.S.C. 102(e) as being clearly anticipated by Huffman (“H2”) (6,694,261)** or *in the alternative* under 35 USC 103 in view of Mallick et al. (inventor, 11/2000; of record; “Hybrid seismic inversion: A reconnaissance tool for deepwater exploration”).

6. de Kok (“dk”) or Huffman 1 or Huffman 2 disclose prestack waveform inversion using a genetic algorithm including:

1. (Currently Amended)
A method for determining shallow water flow risk
comprising:
applying a pre-stack full waveform inversion on the compressional wave seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity;
computing a ratio between the pressure-wave velocity and the shear-wave velocity; and
identifying shallow water flow risk areas using the pressure-wave velocity to the shear-wave velocity ratio.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

2. (Original) The method of claim 1, wherein the seismic data comprises seismic data selected from the list consisting of one-dimensional seismic data, two-dimensional seismic data, and three-dimensional seismic data.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

3. (Original) The method of claim 1, wherein the elastic model further comprises attributes selected from the list consisting of Poisson's ratio.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

4. (Original) The method of claim 1, further comprising processing the seismic data to enhance its stratigraphic resolution.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

5. (Original) The method of claim 4, wherein the processing the seismic data comprises sub-sampling the seismic data to less than two millisecond intervals.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

6. (Original) The method of claim 4, wherein the processing the seismic data comprises using an algorithm with an amplitude preserving flow.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

7. (Original) The method of claim 4, wherein the processing the seismic data comprises using an algorithm selected from the list consisting of a pre-stack time migration, accurate velocity normal-moveout correction, and noise removal algorithms.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

8. (Original) The method of claim 1, wherein the control location comprises a plurality of control locations.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

9. (Original) The method of claim 1, further comprising selecting a control location within the seismic data.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

10. (Original) The method of claim 9, wherein selecting the control location within the seismic data comprises performing a stratigraphic analysis on the seismic data to determine the control location.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

11. (Original) The method of claim 10, wherein performing the stratigraphic analysis comprises developing a geologic model.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

12. (Original) The method of claim 11, wherein performing the stratigraphic analysis comprises identifying the control location by using the geologic model to identify a geologic feature selected from this list consisting of faults, blow-outs, bioherms, chaotic facies, cones, diapers, domes, gas vents, gas mounds, mud volcanoes, popckmarks, scarps, slumps, channels, slope fan deposition, and bottom simulator reflectors.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

13. (Original) The method of claim 9, wherein selecting the control location within the seismic data further comprises evaluating the seismic attributes of the seismic data.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

14. (Original) The method of claim 13, wherein evaluating the seismic attributes comprises using amplitude-variation-with-offset attributes, comprising intercept and gradient.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

15. (Previously Presented) The method of claim 13, wherein evaluating the seismic attributes comprises evaluating polarity changes in reflection coefficient.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

17. (Original) The method of claim 1, wherein the pre-stack waveform inversion comprises applying a genetic algorithm.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

18. (Original) The method of claim 16, wherein the genetic algorithm comprises:
generating a plurality of elastic earth models;
generating pre-stack synthetic seismograms for the elastic earth models;
matching the generated seismograms with the seismic data;
generating a fitness for the elastic earth models;
genetically reproducing the elastic earth models using the fitness for the elastic earth models; and
determining convergence of the reproduced elastic earth models to select the elastic model.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

19. (Original) The method of claim 18, wherein the plurality of elastic earth models comprises a random population of the elastic earth models.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

20. (Currently Amended)
The method of claim -1-8 1, wherein applying the pre- stack full waveform inversion comprises using an exact wave equation having mode conversions and interbed multiple reflections.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

21. (Original) The method of claim 18, wherein matching the generated seismograms with a plurality the seismic data further comprises matching normal moveout of the generated seismograms and the seismic data, and matching reflection amplitudes of the generated seismograms and the seismic data.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

22. (Original) The method of claim 18, wherein genetically reproducing the elastic earth models using the fitness for the elastic earth models comprises:
reproducing the elastic earth models in proportion to the elastic earth models fitness;
randomly crossing over the reproduced elastic earth models; and
mutating the reproduced elastic earth models.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

23. (Original) The method of claim 1, further comprising applying a post-stack inversion on the seismic data using the elastic model to determine the shallow water flow risk over a 3D volume.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

24. (Original) The method of claim 1, wherein the post-stack inversion is performed using an AVO intercept and a pseudo shear-wave data volume.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

25. (Original) The method of claim 1, wherein shallow water flow risk is identified when the pressure-wave velocity compared to the shear-wave velocity is between approximately 3.5 and approximately 7.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

26. (Previously Presented) A computerized method for determining shallow water flow risk using seismic data comprising:
processing the seismic data to enhance its stratigraphic resolution;
selecting a control location comprising:
performing a stratigraphic analysis on the seismic data; and
evaluating the seismic attributes of the seismic data;
applying a pre-stack waveform inversion on the seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure- wave velocity and shear-wave velocity;
applying a post-stack inversion on the seismic data using the elastic model; and
computing a ratio between the pressure-wave velocity and the shear-wave velocity based on the post-stack inverted elastic model to determine the shallow water flow risk.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

27. (Original) The method of claim 26, wherein the pre-stack waveform inversion comprises using a genetic algorithm comprising:
generating a plurality of elastic earth models;
generating pre-stack synthetic seismograms for the elastic earth models;
matching the generated seismograms with the seismic data;
generating a fitness for the elastic earth models;
genetically reproducing the elastic earth models using the fitness for the elastic earth models; and
determining convergence of the reproduced elastic earth models to select the elastic model.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

28. Currently Amended)
A method for determining a shallow water flow risk
area comprising:
applying a pre-stack full waveform inversion on the <u>compressional wave</u> seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity;
computing a ratio between the pressure-wave velocity and the shear-wave velocity; and
identifying an area having the ratio of two or higher as a shallow water flow risk
area.

(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035)

See De Kok:

trace inversion. As input to prestack inversion, the data were corrected for divergence, but not for absorption, and zero-phased without further deconvolution. In spite of a strong compressional wave (P-wave) contrast, the reflection strength of the SWF sands is weak on a stacked section, often making them less visible than other sands. This is due to the Type-II AVO behavior, leading to a polarity reversal at a reflection angle of about 30 to 40 degrees. The prestack inversion process was constrained with initial densities and P-wave velocities. After two iterations, first with a coarse layered model and next with a finer model, the results of Figure 7 were obtained. It shows the discriminating ability of the Vp/Vs ratio. Anomalous high values appear at the levels where SWF layers were experienced during drilling.

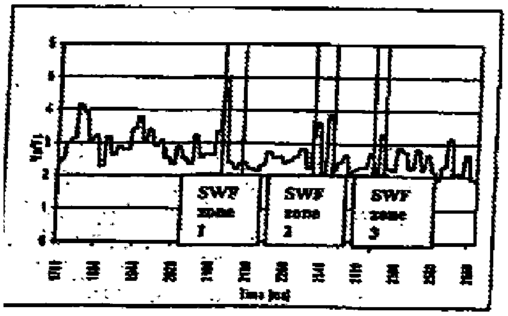

Figure 7: V_p/V_s log obtained from inversion at the Ursa

H1: Page 1033 :

If we consider the range of confining and effective stresses under which SWF sands exist, it is recognized that these materials exist in the transition zone between Wood's equation behavior for slurries and porous load-bearing granular materials that can be modeled using Biot theory. At these conditions, the formation should show modest changes in compressional velocity with the observed pore-pressure changes. In contrast, small changes in pore pressure will cause large changes in shear-wave velocity as the material moves very close to the critical porosity which results in the rigidity, or shear strength, of the material rapidly approaching zero. The combination of these two predictions suggests that the V_P/V_S ratio of these sands may change dramatically under small load changes (Figure 6). The equations of Castagna et al. (1993) suggest that below a certain effective stress, there is a rapid increase in the V_P/V_S ratio (which is directly related to Poisson's ratio). It is reasonable to assume that this is accompanied by a rapid increase in shear-wave attenuation with very small decreases in effective stress. This occurs because rock rigidity is approaching zero (i.e., the sediment is becoming more like a liquid). At higher effective stresses, the rock frame is more rigid and the sediment behaves more like a solid. The region of rapid rigidity loss is a likely candidate for SWF. The loss of rigidity may also be tied back to the strength of the materials and their resistance to liquefaction and formation collapse. Poisson's ratio, the modulus of rigidity, and shear-wave quality factor (Q or attenuation) should be highly anomalous for sands close to failure and prone to SWF.

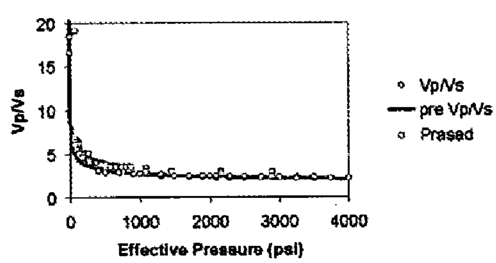

Figure 6. Pulse transmission measurements on brine-saturated sand packs. Open circles are our data which are fit by a power-law empirical relation, as described in the text (solid line). Open squares are measurements from Prasad.

Huffman (US 6,694,261) "H2":

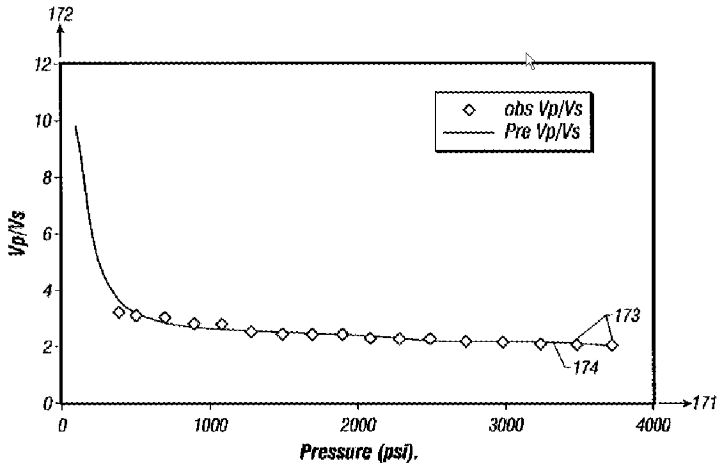

FIG. 3C

U.S. Patent Feb. 17, 2004 Sheet 6 of 16 US 6,694,261 B1

Col. 6:

It is of particular interest to note that the compressional velocities for the data of FIGS. *3b* and *3d* the sands shows relatively little dependence upon the effective stress, and at low stresses, is approximately 2000 meters per second. The Vp/Vs ratio, on the other hand, increases from a value of about 2.5 at 1000 psi to over 6.0 at 20 psi.

An effective stress of 1000 psi corresponds roughly to a subsea depth of approximately 2000 feet for normally pressured sediments. This is within the range where abnormally pressured SWF sands have been encountered in deepwater drilling. What FIGS. *3a–3d* show is that if such a sand is buried and the fluid pressure builds up due to differential compaction or structural geopressuring, there is a small change in the compressional wave velocity and a large change in the shear velocity of the sand. This difference in shear wave velocity will manifest itself as a time delay, or "static" shift in the seismic data that will make the abnormally-pressured SWF sand appear thicker in time on the shear wave data due to the low shear velocities. Additionally, a sand with a shear velocity of 700 to 800 m/s would have a relatively small difference in shear wave impedance with an overlying clay or silt sediments whereas a sand with a shear velocity of 300 m/s or less would have a much larger difference in shear wave impedance with overlying sediments. As would be well known to those versed in the art, such a difference in shear wave impedance should be detectable by suitable seismic methods. What is important for the present invention is that the abnormal pressure in a sand body will produce a small change in compressional velocity and impedance and a large change in shear velocity and impedance: the exact magnitude of the change and the mechanism that causes the change is relatively unimportant.

7. Applicants argue that the applied art does not disclose full wave prestack inversion of compressional waves. It would appear that a full inversion is the "default" inversion because it is "exact" and not approximated as in *partial prestack inversions*. Furthermore, it is noted that *performing inversion on anything other than compressional waves would appear to be meaningless*. It is not clear if Applicants are implying that the art discloses performing inversion on *rarefaction* waves.

8. Therefore, *in the alternative*, the base references are modified in view of Mallick et al. (inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration") discloses:

> Page 1233:
>
> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.
>
> Page 1234
>
> It is also important to note that the full waveform prestack inversion plays a very important role in the hybrid inversion. First of all, it is prestack inversion that provides the low-frequency *P*- and *S*-wave impedance trends for our hybrid inversion. When well data (normally used to define low-frequency impedance trends) are not available, prestack inversion is the only way to obtain this information.
>
> Page 1235
>
> In addition to providing low-frequency trends, prestack inversion can also verify the validity of the poststack inversion. Poststack inversion assumes that every event on seismic data is a primary reflection. If seismic trace amplitudes are contaminated by

> interference effects, poststack inversion will be ambiguous. Prestack inversion, on the other hand, uses a full wave-equation approach that correctly handles such interference effects.

9. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Mallick teaching to include the Mallick teaching because Mallick discloses (page 1233) that:

> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

Claim Rejections - 35 USC § 103

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

12. Claims 1-5, 7-15, 17-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mallick (3/1999) in view of Huffman (**6,694,261**), or *in the alternative* in further view of Mallick

et al. ("m2"; inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration").

13. Mallick discloses all limitations, as subsequently discussed, but does not expressly disclose the application of the technique to Shallow Water Flow (SWF).

14. Huffman discloses a method for identification of shallow water flow hazards using seismic data (see title), using the same types of techniques.

15. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Mallick teaching to include the Huffman teaching because Huffman disclose in the "background of the art" that there is a need to identify SWF prior to drilling a borehole.

16. Specifically, Mallick/Huffman discloses:

1. (Currently Amended)
A method for determining shallow water flow risk
comprising:
applying a pre-stack full waveform inversion on the compressional wave seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity;
computing a ratio between the pressure-wave velocity and the shear-wave velocity; and
identifying shallow water flow risk areas using the pressure-wave velocity to the shear-wave velocity ratio.

(M: pg. 332: Figure 11 compares the observed angle gather at well D with two synthetic angle gathers. Both these synthetic gathers were computed using the same model that was obtained from a run of the GA inversion of prestack seismic data at the given CMP location. One of the synthetic gathers was computed using a full wave equation that included all interbed multiples and mode conversions.; Pg. 333" FIG. 11. Comparison of observed angle gather at wellDlocation with the synthetic angle gathers computed using full wave equation and *P*-wave primaries only. (a) Synthetic angle gather computed with full wave equation. (b) Observed angle gather. (c) Synthetic angle gather computed with *P*-wave primaries only. Arrows indicate (from top) Austin chalk, shale, Woodbine sand.; Pg. 334: To test the contribution of mode-converted and multiple reflections on the final inversion output, prestack inversion was run using primary *P*-wave reflection energy only. Figure 14 shows the results of such an inversion compared with the full GA inversion and poststack inversion. Ignoring mode conversions and multiple reflections generated a substantially inferior inversion result in comparison to that from the full GA inversion.; Pg. 336: **CONCLUSION**In this paper, a method for inversion of prestack seismic data is presented, and the issues relating to a practical implementation of such an inversion methodology are discussed. A comparison of prestack and poststack inversion on a single data set shows the superiority of prestack inversion over poststack inversion. Prestack inversion used in this study is an elastic full waveform inversion that provides estimates of *P*-wave acoustic impedance and Poisson's ratio. These are useful parameters in lithology discrimination and direct detection of hydrocarbons from seismic data.) seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity; "Genetic Algorithm – a Practical Implementation – pp. 326-330; ; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)2. (Original) The method of claim 1, wherein the seismic

data comprises seismic data selected from the list consisting of one-dimensional seismic data, two-dimensional seismic data, and three-dimensional seismic data.; ("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49).

Re ratio: Huffman (US 6,694,261) :

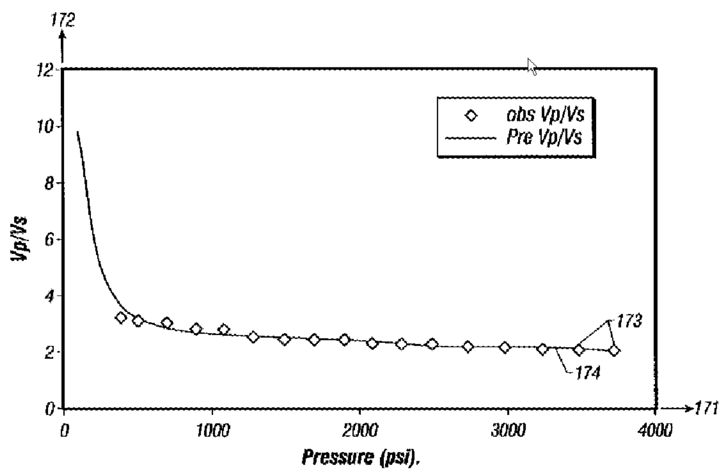

FIG. 3C

U.S. Patent Feb. 17, 2004 Sheet 6 of 16 US 6,694,261 B1

It is of particular interest to note that the compressional velocities for the data of FIGS. 3*b* and 3*d* the sands shows relatively little dependence upon the effective stress, and at low stresses, is approximately 2000 meters per second. The Vp/Vs ratio, on the other hand, increases from a value of about 2.5 at 1000 psi to over 6.0 at 20 psi.

An effective stress of 1000 psi corresponds roughly to a subsea depth of approximately 2000 feet for normally pressured sediments. This is within the range where abnormally pressured SWF sands have been encountered in deepwater drilling. What FIGS. 3*a*–3*d* show is that if such a sand is buried and the fluid pressure builds up due to differential compaction or structural geopressuring, there is a small change in the compressional wave velocity and a large change in the shear velocity of the sand. This difference in shear wave velocity will manifest itself as a time delay, or "static" shift in the seismic data that will make the abnormally-pressured SWF sand appear thicker in time on the shear wave data due to the low shear velocities. Additionally, a sand with a shear velocity of 700 to 800 m/s would have a relatively small difference in shear wave impedance with an overlying clay or silt sediments whereas a sand with a shear velocity of 300 m/s or less would have a much larger difference in shear wave impedance with overlying sediments. As would be well known to those versed in the art, such a difference in shear wave impedance should be detectable by suitable seismic methods. What is important for the present invention is that the abnormal pressure in a sand body will produce a small change in compressional velocity and impedance and a large change in shear velocity and impedance: the exact magnitude of the change and the mechanism that causes the change is relatively unimportant.

Col. 6:

3. (Original) The method of claim 1, wherein the elastic model further comprises attributes selected from the list consisting of density, Poisson's ratio, and Lame elastic parameters.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
4. (Original) The method of claim 1, further comprising processing the seismic data to enhance its stratigraphic resolution.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
5. (Original) The method of claim 4, wherein the processing the seismic data comprises sub-sampling the seismic data to less than two millisecond intervals.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
6. (Original) The method of claim 4, wherein the processing the seismic data comprises using an algorithm with an amplitude preserving flow.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
7. (Original) The method of claim 4, wherein the processing the seismic data comprises using an algorithm selected from the list consisting of a pre-stack time migration, accurate velocity normal-moveout correction, and noise removal algorithms.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
8. (Original) The method of claim 1, wherein the control location comprises a plurality of control locations.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
9. (Original) The method of claim 1, further comprising selecting a control location within the seismic data.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
10. (Original) The method of claim 9, wherein selecting the control location within the seismic data comprises performing a stratigraphic analysis on the seismic data to determine the control location.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
11. (Original) The method of claim 10, wherein performing the stratigraphic analysis comprises developing a geologic model.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
12. (Original) The method of claim 11, wherein performing the stratigraphic analysis comprises identifying the control location by using the geologic model to identify a geologic feature selected from this list consisting of faults, blow-outs, bioherms, chaotic facies, cones, diapers, domes, gas vents, gas mounds, mud volcanoes, popckmarks, scarps, slumps, channels, slope fan deposition, and bottom simulator reflectors.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
13. (Original) The method of claim 9, wherein selecting the control location within the seismic data further comprises evaluating the seismic attributes of the seismic data.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
14. (Original) The method of claim 13, wherein evaluating the seismic attributes comprises using amplitude-variation-with-offset attributes, comprising intercept and gradient.
(“Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)
15. (Previously Presented) The method of claim 13, wherein evaluating the seismic attributes comprises evaluating polarity changes in reflection coefficient.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

17. (Original) The method of claim 1, wherein the pre-stack waveform inversion comprises applying a genetic algorithm.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

18. (Original) The method of claim 16, wherein the genetic algorithm comprises:
generating a plurality of elastic earth models;
generating pre-stack synthetic seismograms for the elastic earth models;
matching the generated seismograms with the seismic data;
generating a fitness for the elastic earth models;
genetically reproducing the elastic earth models using the fitness for the elastic earth models; and
determining convergence of the reproduced elastic earth models to select the elastic model.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

19. (Original) The method of claim 18, wherein the plurality of elastic earth models comprises a random population of the elastic earth models.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

20. (Currently Amended)
The method of claim 18, wherein applying the pre- stack full waveform inversion comprises using an exact wave equation having mode conversions and interbed multiple reflections.

(M: pg. 332: Figure 11 compares the observed angle gather at well D with two synthetic angle gathers. Both these synthetic gathers were computed using the same model that was obtained from a run of the GA inversion of prestack seismic data at the given CMP location. One of the synthetic gathers was computed using a full wave equation that included all interbed multiples and mode conversions.; Pg. 333" FIG. 11. Comparison of observed angle gather at wellDlocation with the synthetic angle gathers computed using full wave equation and *P*-wave primaries only. (a) Synthetic angle gather computed with full wave equation. (b) Observed angle gather. (c) Synthetic angle gather computed with *P*-wave primaries only. Arrows indicate (from top) Austin chalk, shale, Woodbine sand.; Pg. 334: To test the contribution of mode-converted and multiple reflections on the final inversion output, prestack inversion was run using primary *P*-wave reflection energy only. Figure 14 shows the results of such an inversion compared with the full GA inversion and poststack inversion. Ignoring mode conversions and multiple reflections generated a substantially inferior inversion result in comparison to that from the full GA inversion.; Pg. 336: **CONCLUSION**In this paper, a method for inversion of prestack seismic data is presented, and the issues relating to a practical implementation of such an inversion methodology are discussed. A comparison of prestack and poststack inversion on a single data set shows the superiority of prestack inversion over poststack inversion. Prestack inversion used in this study is an elastic full waveform inversion that provides estimates of *P*-wave acoustic impedance and Poisson's ratio. These are useful parameters in lithology discrimination and direct detection of hydrocarbons from seismic data.) seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity; "Genetic Algorithm – a Practical Implementation – pp. 326-330; ; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)2. (Original) The method of claim 1, wherein the seismic data comprises seismic data selected from the list consisting of one-dimensional seismic data, two-dimensional seismic data, and three-dimensional seismic data.; ("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49).

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

21. (Original) The method of claim 18, wherein matching the generated seismograms with a plurality the seismic data further comprises matching normal moveout of the generated seismograms and the seismic data, and matching reflection amplitudes of the generated seismograms and the seismic data.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

22. (Original) The method of claim 18, wherein genetically reproducing the elastic earth models using the fitness for the elastic earth models comprises:
reproducing the elastic earth models in proportion to the elastic earth models fitness;
randomly crossing over the reproduced elastic earth models; and
mutating the reproduced elastic earth models.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

23. (Original) The method of claim 1, further comprising applying a post-stack inversion on the seismic data using the elastic model to determine the shallow water flow risk over a 3D volume.
(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035).

24. (Original) The method of claim 1, wherein the post-stack inversion is performed using an AVO intercept and a pseudo shear-wave data volume.
(dk: sections entitled method, Shallow waterflow detection, and Conclusion. Note fig. 1-2, 7; H2: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49; H1: fig. 6-9; page 1033, col. 2 to first paragraph, page 1035).

25. (Original) The method of claim 1, wherein shallow water flow risk is identified when the pressure-wave velocity compared to the shear-wave velocity is between approximately 3.5 and approximately 7.

("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

26. (Previously Presented) A computerized method for determining shallow water flow risk using seismic data comprising:
processing the seismic data to enhance its stratigraphic resolution;
selecting a control location comprising:
performing a stratigraphic analysis on the seismic data; and
evaluating the seismic attributes of the seismic data;
applying a pre-stack waveform inversion on the seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure- wave velocity and shear-wave velocity;
applying a post-stack inversion on the seismic data using the elastic model; and
computing a ratio between the pressure-wave velocity and the shear-wave velocity based on the post-stack inverted elastic model to determine the shallow water flow risk.

(M: pg. 332: Figure 11 compares the observed angle gather at well D with two synthetic angle gathers. Both these synthetic gathers were computed using the same model that was obtained from a run of the GA inversion of prestack seismic data at the given CMP location. One of the synthetic gathers was computed using a full wave equation that included all interbed multiples and mode conversions.; Pg. 333" FIG. 11. Comparison of observed angle gather at wellDlocation with the synthetic angle gathers computed using full wave equation and *P*-wave primaries only. (a) Synthetic angle gather computed with full wave equation. (b) Observed angle gather. (c) Synthetic angle gather computed with *P*-wave primaries only. Arrows indicate (from top) Austin chalk, shale, Woodbine sand.; Pg. 334: To test the contribution of mode-converted and multiple reflections on the final inversion output, prestack inversion was run using primary *P*-wave reflection energy only. Figure 14 shows the results of such an inversion compared with the full GA inversion and poststack inversion. Ignoring mode conversions and multiple reflections generated a substantially inferior inversion result in comparison to that from the full GA inversion.; Pg. 336: **CONCLUSION**In this paper, a method for inversion of prestack seismic data is presented, and the issues relating to a practical implementation of such an inversion methodology are discussed. A comparison of prestack and poststack inversion on a single data set shows the superiority of prestack inversion over poststack inversion. Prestack inversion used in this study is an elastic full waveform inversion that provides estimates of *P*-wave acoustic impedance and Poisson's ratio. These are useful parameters in lithology discrimination and direct detection of hydrocarbons from seismic data.) seismic data at a selected control

location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity; "Genetic Algorithm – a Practical Implementation – pp. 326-330; ; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)2. (Original) The method of claim 1, wherein the seismic data comprises seismic data selected from the list consisting of one-dimensional seismic data, two-dimensional seismic data, and three-dimensional seismic data.; ("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49).
; Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

27. (Original) The method of claim 26, wherein the pre-stack waveform inversion comprises using a genetic algorithm comprising:
generating a plurality of elastic earth models;
generating pre-stack synthetic seismograms for the elastic earth models;
matching the generated seismograms with the seismic data;
generating a fitness for the elastic earth models;
genetically reproducing the elastic earth models using the fitness for the elastic earth models; and
determining convergence of the reproduced elastic earth models to select the elastic model.
("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)

28. Currently Amended)
A method for determining a shallow water flow risk
area comprising:
applying a pre-stack full waveform inversion on the <u>compressional wave </u>seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity;
computing a ratio between the pressure-wave velocity and the shear-wave velocity; and
identifying an area having the ratio of two or higher as a shallow water flow risk
area.

(M: pg. 332: Figure 11 compares the observed angle gather at well D with two synthetic angle gathers. Both these synthetic gathers were computed using the same model that was obtained from a run of the GA inversion of prestack seismic data at the given CMP location. One of the synthetic gathers was computed using a full wave equation that included all interbed multiples and mode conversions.; Pg. 333" FIG. 11. Comparison of observed angle gather at wellDlocation with the synthetic angle gathers computed using full wave equation and *P*-wave primaries only. (a) Synthetic angle gather computed with full wave equation. (b) Observed angle gather. (c) Synthetic angle gather computed with *P*-wave primaries only. Arrows indicate (from top) Austin chalk, shale, Woodbine sand.; Pg. 334: To test the contribution of mode-converted and multiple reflections on the final inversion output, prestack inversion was run using primary *P*-wave reflection energy only. Figure 14 shows the results of such an inversion compared with the full GA inversion and poststack inversion. Ignoring mode conversions and multiple reflections generated a substantially inferior inversion result in comparison to that from the full GA inversion.; Pg. 336: **CONCLUSION**In this paper, a method for inversion of prestack seismic data is presented, and the issues relating to a practical implementation of such an inversion methodology are discussed. A comparison of prestack and poststack inversion on a single data set shows the superiority of prestack inversion over poststack inversion. Prestack inversion used in this study is an elastic full waveform inversion that provides estimates of *P*-wave acoustic impedance and Poisson's ratio. These are useful parameters in lithology discrimination and direct detection of hydrocarbons from seismic data.) seismic data at a selected control location to provide an elastic model, wherein the elastic model comprises pressure-wave velocity and shear-wave velocity; "Genetic Algorithm – a Practical Implementation – pp. 326-330; ; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49)2. (Original) The method of claim 1, wherein the seismic data comprises seismic data selected from the list consisting of one-dimensional seismic data, two-dimensional seismic data, and three-dimensional seismic data.; ("Genetic Algorithm – a Practical Implementation – pp. 326-330; H: col. 6, lines 6-54, col, 6; col. 11, line 60 to col. 12, line 49).

17. Applicants argue that the applied art does not disclose full wave prestack inversion of compressional waves. It would appear that a full inversion is the "default" inversion because it is "exact" and not approximated as in *partial prestack inversions*. Furthermore, it is noted that *performing inversion on anything other than compressional waves would appear to be meaningless*. It is not clear if Applicants are implying that the art discloses performing inversion on *rarefaction* waves.

18. Therefore, *in the alternative*, the base references are modified in view of Mallick et al. (inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration") discloses:

Page 1233:

> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

Page 1234

> It is also important to note that the full waveform prestack inversion plays a very important role in the hybrid inversion. First of all, it is prestack inversion that provides the low-frequency *P*- and *S*-wave impedance trends for our hybrid inversion. When well data (normally used to define low-frequency impedance trends) are not available, prestack inversion is the only way to obtain this information.

Page 1235

> In addition to providing low-frequency trends, prestack inversion can also verify the validity of the poststack inversion. Poststack inversion assumes that every event on seismic data is a primary reflection. If seismic trace amplitudes are contaminated by interference effects, poststack inversion will be ambiguous. Prestack inversion, on the other hand, uses a full wave-equation approach that correctly handles such interference effects.

19. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Mallick teaching to include the Mallick teaching because Mallick discloses (page 1233) that:

> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in <u>*prestack inversion*</u>. <u>*Our inversion uses a full wave-equation approach*</u> that takes all primary, mode-converted, and <u>interbed multiple reflections</u> into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

20. Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mallick (3/1999) in view of Huffman (6,694,261) and in further view of Tygel et al. *or* de Kok in view of Tygel et al., or *in the alternative* in further view of Mallick et al. ("m2"; inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration").

21. Mallick *or* de Kok discloses all limitations, as discussed, but do not expressly disclose the use of amplitude preserving techniques.

22. Tygel et al. discloses the use of amplitude preserving techniques (page 945, top of middle column).

23. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Mallick or de Kok teaching to incorporate the Tygel et al. teaching because Tygel et al. disclose that the use of amplitude preserving techniques reduce the deleterious effects of aliasing (page 945, top of middle column), in the same context.

24. In *the alternative*, the base references are modified in view of Mallick et al. (inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration") discloses:

Page 1233:

Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

Page 1234

It is also important to note that the full waveform prestack inversion plays a very important role in the hybrid inversion. First of all, it is prestack inversion that provides the low-frequency *P*- and *S*-wave impedance trends for our hybrid inversion. When well data (normally used to define low-frequency impedance trends) are not available, prestack inversion is the only way to obtain this information.

Page 1235

In addition to providing low-frequency trends, prestack inversion can also verify the validity of the poststack inversion. Poststack inversion assumes that every event on seismic data is a primary reflection. If seismic trace amplitudes are contaminated by interference effects, poststack inversion will be ambiguous. Prestack inversion, on the other hand, uses a full wave-equation approach that correctly handles such interference effects.

25. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Mallick teaching to include the Mallick teaching because Mallick discloses (page 1233) that:

> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

Response to Arguments

26. Applicant's arguments, filed 11/5/2007 have been carefully considered, but are not persuasive.

27. Applicant's arguments relating to the art rejections are not persuasive. Only new arguments are addressed herein, unless otherwise noted.

28. Applicant's arguments regarding the 102(a) rejections and 103 rejections based upon 102(a) are not persuasive because the inventive entities are different. Arguments regarding the requirement for prior art label of the drawings are therefore not persuasive.

29. With respect to the amended limitations, Applicants argue generally:

> Claims 1-5 and 7-28 stand rejected under 35 USC 102(e) as being anticipated by US Patent No. 6,694,261 ("H2"). Claims 1 and 28 have been significantly amended to recite "applying a pre-stack full waveform inversion on compressional wave seismic

30. As skilled artisans are aware, a full wave prestack inversion is the "default" inversion (actually a step back in the art) because it is "exact" and not approximated as in *partial prestack inversions*. Riel et al. (6,665,615) is cited as rebuttal evidence:

"Brief Summary Text - BSTX (10):

In the literature and in prior patents several methods have been discussed which attempt to utilize the information contained in the change of amplitudes in seismic data with changing angle to determine information about elastic parameters and compositional parameters. U.S. Pat. No. 5,583,825 (Carrazone et al.) provides relevant literature references and discusses prior patents. *Where these prior methods utilize inversion to estimate elastic or compositional parameters, they propose to use the full prestack seismic data* and propose to also estimate the background velocity trend model as part of the method. These methods are computationally very demanding and complex.

Brief Summary Text - BSTX (13):

In a preferred embodiment the method according to the invention *uses a series of processed seismic full and/or partial stacks data as input instead of the full prestack seismic data*, assumes that a background trend model for the parameters is known and utilizes further external information provided by rock physics and other relationships. This results in a highly practical, widely applicable new process to estimate subsurface elastic parameters and compositional parameters. ”

31. Furthermore, it is noted that *performing inversion on anything other than compressional waves would appear to be meaningless*. It is not clear if Applicants are implying that the art discloses performing inversion on *rarefaction* waves. Clarification is requested. Furthermore, as skilled artisans are aware, “P” waves are compressional waves. If Applicants have evidence to the contrary, they are kindly requested to provide it.

32. Note that Mallick et al. (*Shallow water flow prediction using prestack waveform inversionof conventional 3D seismic data and rock modeling*; 2002) provides buttressing evidence:

> “For prestack inversion, we use the genetic algorithm (GA) based methodology developed by Mallick (1995, 1999) which allows accurate estimates of V_P, V_S, and bulk density as functions of time and depth at the selected locations. The GA prestack inversion is an optimization algorithm that finds a suitable earth model by minimizing the misfit between observed and synthetic data traces. *It should be noted that the GA uses an exact wave equation based forward modeling*, which allows one to calculate all primary, multiple, and mode-converted reflections.”

. With respect to Huffman (H1), Applicants argue:

> Applicants respectfully submit that H1 does not teach or disclose applying a pre-stack full waveform inversion on compressional wave seismic data. In contrast, H1 requires multicomponent data for SWF detection. As further contrast, H1 mentions nothing about applying a pre-stack full waveform inversion. Accordingly, claim 1 is patentable over H1. Claims 2-5 and 7-25 are also patentable over H1 since they depend from claim 1. Withdrawal of the rejection is respectfully requested.

There is no reason to believe that the prestack inversion is other than "full" and Applicants have provided no explanation thereto. Furthermore, Applicants have not explained why requiring multicomponent data precludes full inversion.

33. Regardless, Mallick et al. (inventor, 11/2000; of record; "Hybrid seismic inversion: A reconnaissance tool for deepwater exploration") discloses:

Page 1233:

> Comparison of Figures 1b and 1c demonstrates the need for fine discretization of the earth models in *prestack inversion*. *Our inversion uses a full wave-equation approach* that takes all primary, mode-converted, and interbed multiple reflections into account. To correctly model all stratigraphic details of the subsurface, inclusion of mode conversions and interbed multiple reflections is necessary. In addition, to correctly model thin-bed tuning effects due to these mode conversions and multiple reflections, it is necessary to discretize the earth model to one-fourth of the dominant wavelength of the input seismic data.

Page 1234

> It is also important to note that the full waveform prestack inversion plays a very important role in the hybrid inversion. First of all, it is prestack inversion that provides the low-frequency P- and S-wave impedance trends for our hybrid inversion. When well data (normally used to define low-frequency impedance trends) are not available, prestack inversion is the only way to obtain this information.

Page 1235

> In addition to providing low-frequency trends, prestack inversion can also verify the validity of the poststack inversion. Poststack inversion assumes that every event on seismic data is a primary reflection. If seismic trace amplitudes are contaminated by interference effects, poststack inversion will be ambiguous. Prestack inversion, on the other hand, uses a full wave-equation approach that correctly handles such interference effects.

34. Any inquiry concerning this communication or earlier communications from the examiner should be:

directed to: Dr. Hugh Jones telephone number (571) 272-3781,

Monday-Thursday 0830 to 0700 ET,

or

the examiner's supervisor, Kamini Shah, telephone number (571) 272-2279.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist, telephone number (703) 305-3900.

mailed to:

Commissioner of Patents and Trademarks

Washington, D.C. 20231

or faxed to:

(703) 308-9051 (for formal communications intended for entry)

or (703) 308-1396 (for informal or draft communications, please label *PROPOSED* or *DRAFT*).

/Hugh Jones/

Primary Examiner, Art Unit 2128

February 17, 2008